Purposeful practicals

- Identify the different roles of science practicals in learning.
- Predict problems and plan to avoid them

ITTECF SECTION 3 A school's curriculum enables it to set out its vision for the knowledge, skills and values that its pupils will learn, encompassing the national curriculum within a coherent wider vision for successful learning. 2. Secure subject knowledge helps teachers to motivate pupils and teach effectively.

Using resources and materials aligned with the school curriculum (e.g. textbooks or shared resources designed by expert colleagues that carefully sequence content)

Planning for purposeful practicals VEVOX.APP 154-063-260

When?

Why?

Lecture code XO-IN-GG

Changes from prior experience of learning, supporting or teaching science

- Class size
- Availability of resources
- Familiarity with resources
- School culture

Guidance from the Gatsby report

THE FIVE PURPOSES OF PRACTICAL SCIENCE

A	TO TEACH THE PRINCIPLES OF SCIENTIFIC INQUIRY
B	TO IMPROVE UNDERSTANDING OF THEORY THROUGH PRACTICAL EXPERIENCE
C	TO TEACH SPECIFIC PRACTICAL SKILLS, SUCH AS MEASUREMENT AND OBSERVATION, THAT MAY BE USEFUL IN FUTURE STUDY OR EMPLOYMENT
D	TO MOTIVATE AND ENGAGE STUDENTS
E	TO DEVELOP HIGHER LEVEL SKILLS AND ATTRIBUTES SUCH AS COMMUNICATION, TEAMWORK AND PERSEVERANCE

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Gatsby report “Good Practical Science”, 2017

Aims of national curriculum

- Develop science knowledge and conceptual understanding through the specific disciplines of biology, chemistry and physics
- Develop understanding of the nature, processes and methods of science through different types of science enquiries that help them to answer scientific questions about the world around them
- Equip them with the scientific knowledge required to understand the uses and implication of science, today and for the future

Is practical work successful?

What are your experiences of practical work at secondary school level?

What makes practical work successful?

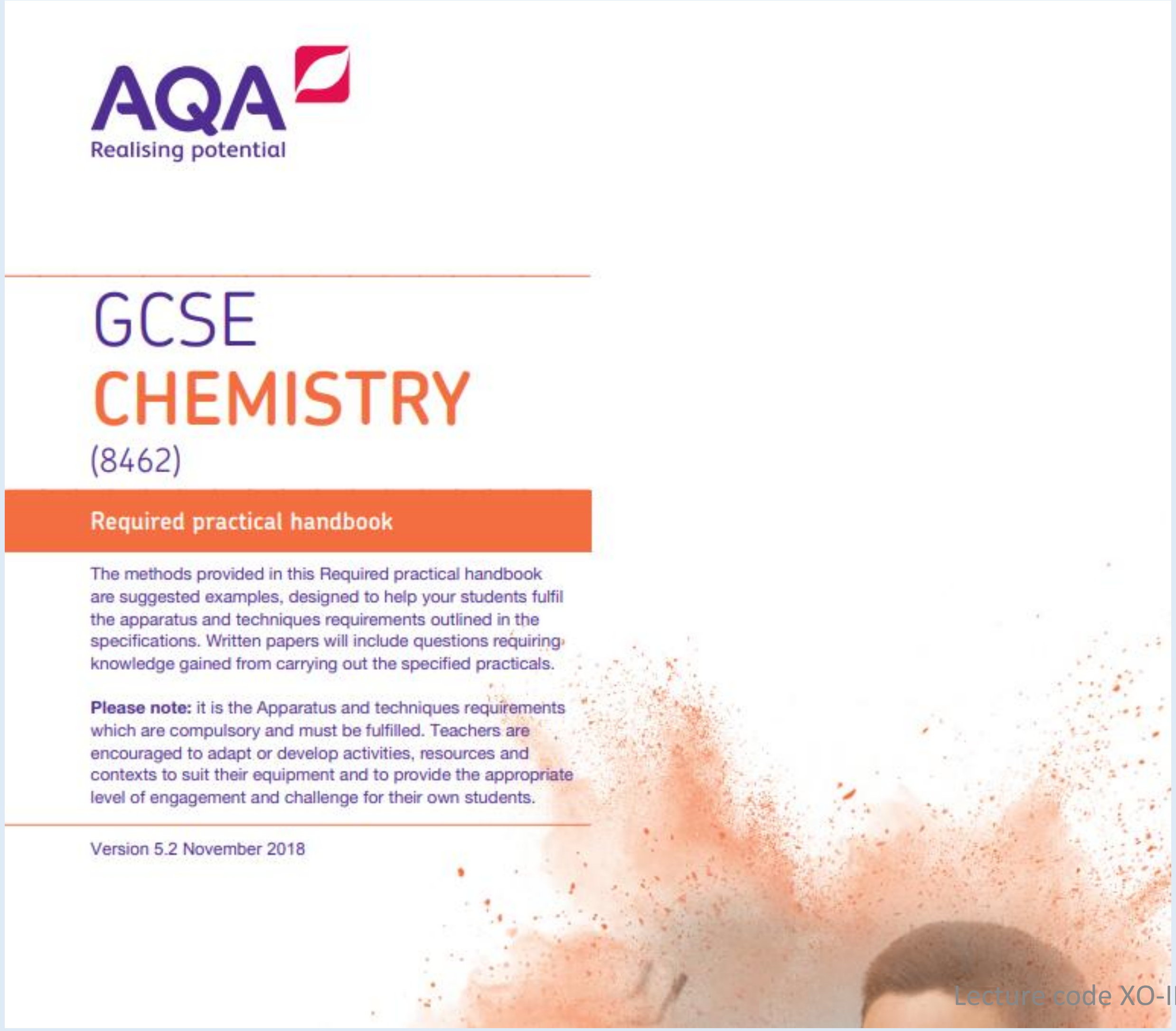
'Recipe' nature

Table 1: Assessing effectiveness of a practical in terms of whether it is 'hands on' or 'minds on'

Adapted from Millar and Abrahams, 2009.[41]

	Assessing if a practical activity is 'hands on'	Assessing if a practical activity is 'minds on'
Do the pupils do what is intended?	Pupils do what was intended with the objects and materials provided, and make the intended observations.	During the activity, pupils think about what they are doing and observing, using the ideas intended in the activity.
Do the pupils learn what is intended?	Pupils can later recall and describe what they did in the activity and what they observed.	Pupils can later discuss the activity using the ideas it was aiming to develop.

An example required practical. What are your thoughts on CLT?- We will return to this later


AQA
Realising potential

GCSE
CHEMISTRY
(8462)

Required practical handbook

The methods provided in this Required practical handbook are suggested examples, designed to help your students fulfil the apparatus and techniques requirements outlined in the specifications. Written papers will include questions requiring knowledge gained from carrying out the specified practicals.

Please note: it is the Apparatus and techniques requirements which are compulsory and must be fulfilled. Teachers are encouraged to adapt or develop activities, resources and contexts to suit their equipment and to provide the appropriate level of engagement and challenge for their own students.

Version 5.2 November 2018

What does the educational research say?

Abrahams and Reiss (2012)

The authors critique the centrality of practical work to learning in science. Observations of pupils' abilities to manipulate objects in accordance with teacher intentions, and their acquisition of ideas in the way the teacher intended, were assessed. The assessment was carried out by evaluating a small sample of pupil responses and actions, using a framework of outcomes for the topic being studied. Primary school lessons spent less time on the manipulation of objects or materials but more time teaching the target concepts, commonly through developing the understanding of key vocabulary. Conversely, secondary teachers focus more on the manipulative elements of the activity; this is seen as a 'trade off' between 'hands on' and 'minds on' learning by both teachers and researchers. The researchers did not find evidence that practical activities helped to develop scientific understanding, though they did provide 'anchorage' for descriptive recall. Further, and more explicit, scaffolding of understanding is required if practical work is to engender the intended learning.

A good learning experience?

Where's the evidence?

Different studies on practical work tend to focus on different purposes which makes reaching a consensus view about the impact of practical work difficult and there are few studies that compare the effectiveness of different types of practical activity. However, evidence suggests that:

- practical science engages pupils;
- due to the wide variety of aims and purposes of practical work, it is important to be clear about your purpose for choosing a particular activity as different types of practical work are needed to achieve different aims;
- practical work has positive impacts on the development of specific practical skills;
- there are benefits of developing scientific reasoning skills through practical work and this can impact on pupil attainment; and
- open ended research projects can have impacts on skill development, pupil attitudes, and attainment.

EEF Improving Secondary Science report

Round robin of practicals

- In pairs decide the purpose of each practical. There may be more than one reason for completing the practical.
- Consider how you would use the activity. How would you set the practical up? What do you need to consider? Would you complete the practical in a lesson or in a science club?
- What are they trying to teach? Where does it fit into the national curriculum? To view the national curriculum for science click here. We are looking at KS3 and KS4.

Diffusion

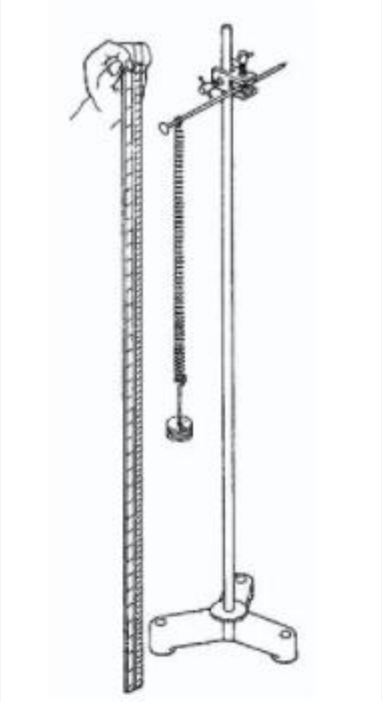
- Have two beakers in the first beaker have cold water in the second have warm/hot water. Add 1 crystal of potassium permanganate to each beaker and record your results.

Potato chips in Osmosis

Method

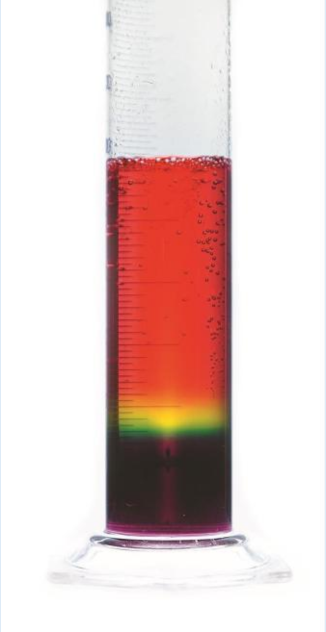
- Cut three strips of potato use a cork borer. Ensure they are roughly 3cm in length. Measure the mass of each chip.
- In 3 separate boiling tubes add one of the potato chips. Into the first boiling tube add 20cm^3 of 1% sugar solution.
- Into the second boiling tube add 20cm^3 of 2% sugar solution
- Into the third boiling tube add 20cm^3 of 5% sugar solution.
- After 24 hours re-record the mass.

Hookes Law



1. Add 1N to your spring and measure its extension (change in length)
2. Continue to add 1N masses and recording the extension up to a max of 8N
3. Draw a graph of force against extension

Rainbow fizz



Chemicals can combine to produce some really interesting colours and effects. As you carry out this practical you will need to make detailed observations and think carefully about what you can conclude.

Method

- Put 2 spatulas of sodium carbonate in a test tube.
- Add 5ml of water and shake thoroughly.
- Add 3 drops of universal indicator.
- Measure 5ml of ethanoic acid in another test tube.
- Gradually add the ethanoic acid drop by drop to the first test tube.

Barriers still exist so we need new approaches to teach practical work

- "required" practicals
- Knowledge rich curriculum.
- Limited time to combine both subtsantive and disciplinary knowledge.
- Year 11 becomes a revision year prior to GCSEs.
- Cognitive load and working memory

Read the article on Purposeful practicals by Lisa Naveen

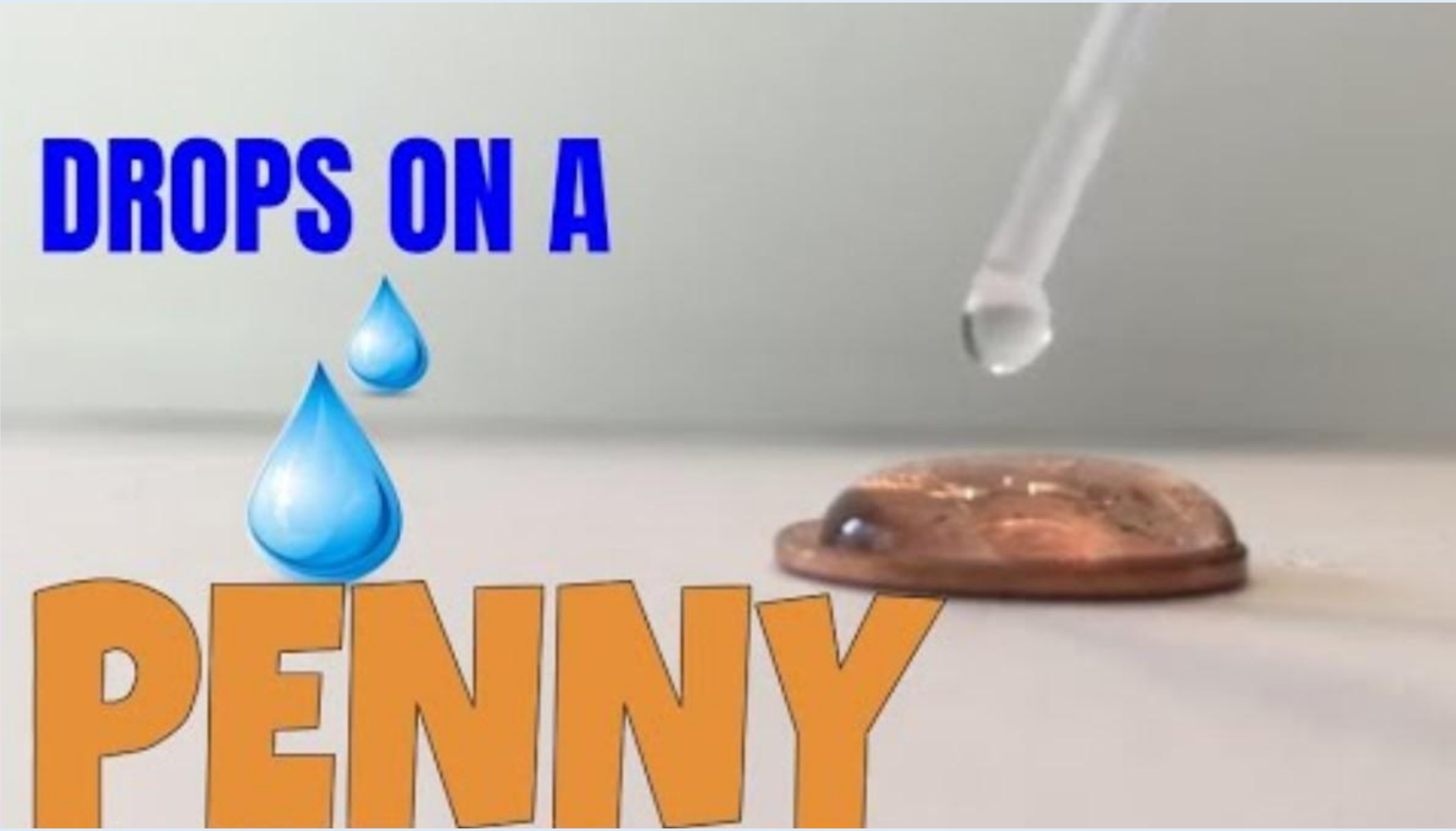
- [Build confidence with guided, active and purposeful practicals | Ideas | RSC Education]

- The article is also available on Moodle

Is this a purposeful practical?

- Watch the video and think about how the practical is set up. (I'm showing you a video rather than getting you (in your case the children in the class) to do the practical for themselves

- What substantive knowledge/disciplinary knowledge (working scientifically skills can be covered) How does this link to the national curriculum? Hint think intermolecular forces.

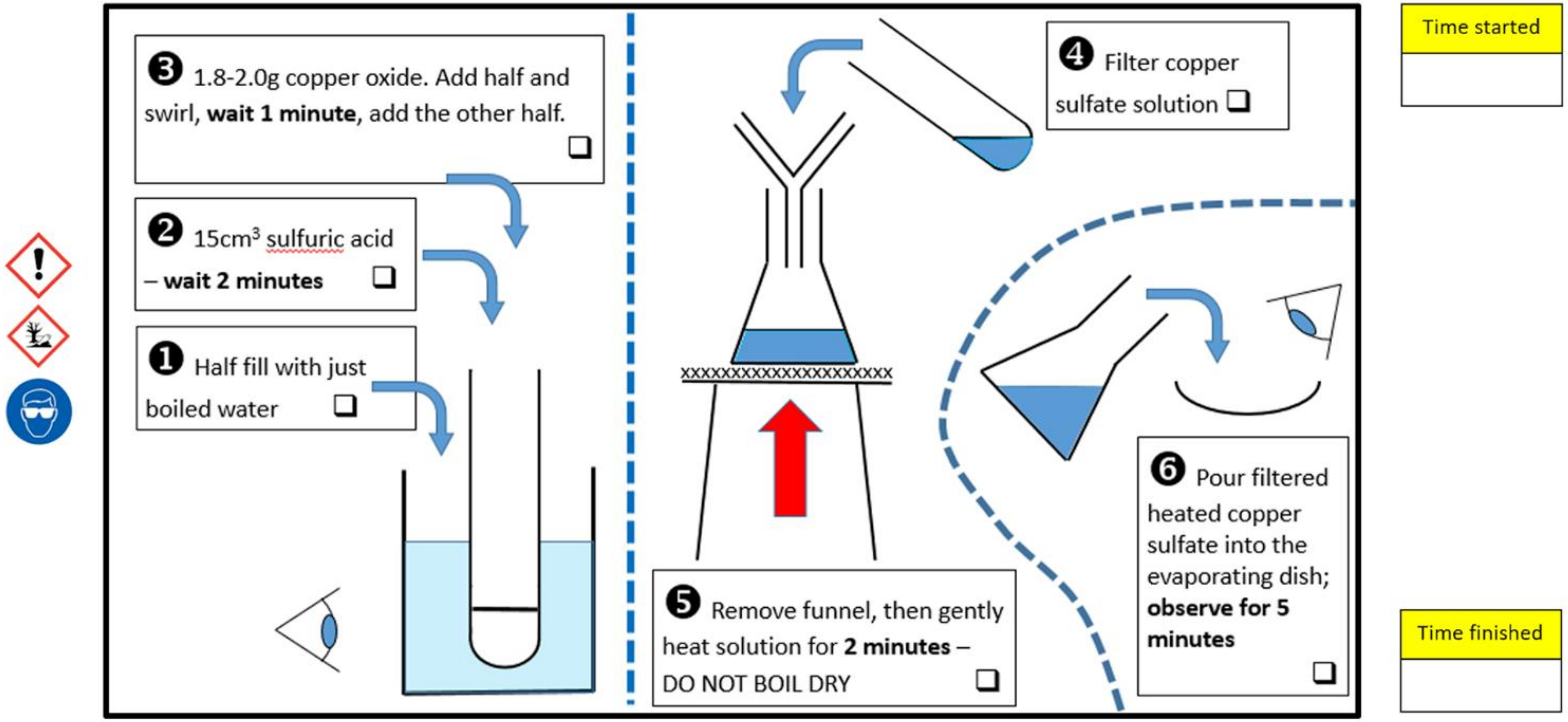


Instructions on practicals David Patterson available [here]

Making copper sulfate

In this activity

- React copper oxide with sulfuric acid
- Filter the copper sulfate solution
- Evaporate some of the water
- Crystallise the copper sulfate



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Patterson, D. (2019) Design and evaluation of integrated instructions in secondary level chemistry work. *Journal of chemistry education*. **96**(11),pp. 2510–2517

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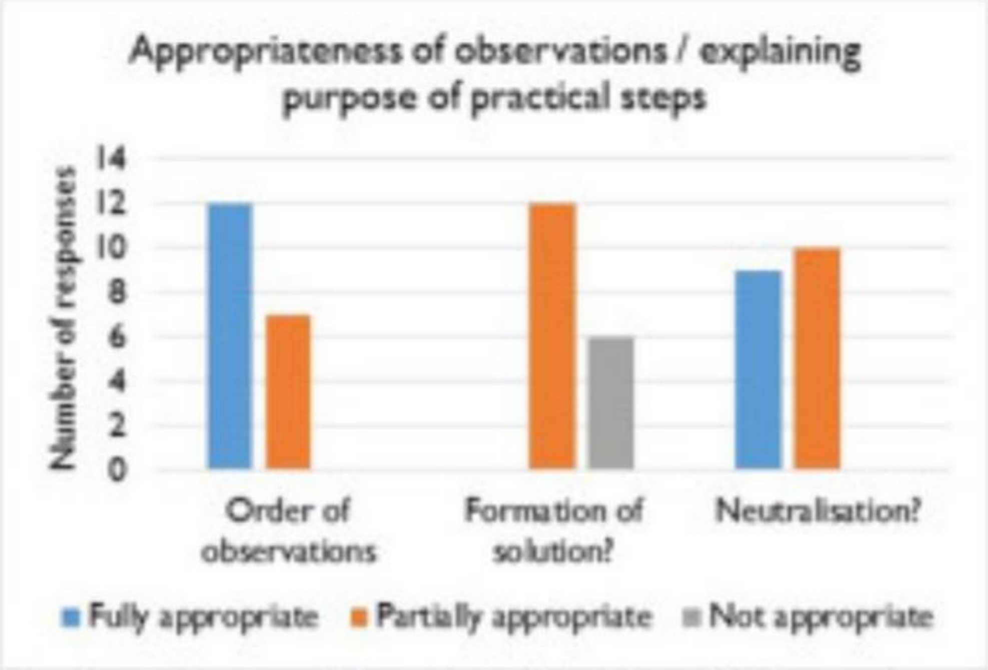
Some early data:

❹

Three teaching groups have carried out four different practical activities.

General themes:

- all students completed the activities and none found them hard;
- **most students found the clarity of the instructions helpful in understanding what they were doing;**
- some students found the ability to visualise what they were doing helped with their confidence;
- **there was a mixed picture on how well students understood what they had done / observed.** ☑



What are the opportunities afforded by or barriers to using practicals in the teaching pedagogy of early career teachers?

Students must be made aware of specific words / apparatus in order to gain marks in exam questions. A lot more emphasis is put onto key words and points that students need to be aware of. Students then struggle to develop practical skills

The practical very rarely works in the lesson anyway. So quite often it's, well, actually, rather than spend 50 minutes on this, which I don't have because we've got to get to a certain point before the end of the year, it's instead, they watch a five minute video and do the questions on it.

A new approach to teaching practicals

- Microscale practicals

- Read the article on microscale practicals written by Campbell and Eburne. This is available at Microscale makes teachers (and learners) mighty confident | Feature | RSC Education and is also available on Moodle

Examples of the microscale activities

QUALITATIVE ANALYSIS - Cations / Positive ions

Flame tests can be used to identify some positive ions such as sodium, lithium, potassium and copper.

Other positive ions can be identified by their reaction with sodium hydroxide solution and ammonia solution.

Use the grid to test the reaction of some positive ions with

- sodium hydroxide solution
- excess sodium hydroxide solution
- ammonia solution
- excess ammonia solution

Record your results for each ion.

Ions tested / Reagent added	2 drops $Cu2+$ ↓	2 drops $Fe2+$ ↓	2 drops $Fe3+$ ↓	2 drops $Ca2+$ ↓	2 drops $Al3+$ ↓
1 drop H_2O →					
1 drop NaOH →					
5 drops NaOH →					

QUALITATIVE ANALYSIS - Anions / Negative ions

- Follow the procedure outlined in each section to test for carbonates, halides and sulphates.
- Record your observations.
- Describe the test for each negative ion and try to explain the chemistry.

Testing for carbonate ions, CO_3^{2-}

- Add 2 drops of the appropriate anion solution to each square, as indicated.
- Add 1 drop of Universal Indicator and stir carefully.
- Add 1 drop of hydrochloric acid to any solution that is alkaline (turned blue).

Chloride, Cl^-	Bromide, Br^-	Iodide, I^-	Carbonate, CO_3^{2-}	Sulphate, SO_4^{2-}

Testing for halide ions, Cl^-, Br^-, I^-

- Add 2 drops of the appropriate anion solution to each square, as indicated.
- Add 2 drops of nitric acid followed by 1 drop of silver nitrate solution.
- Add 2 drops of ammonia solution to square with a precipitate and stir carefully.

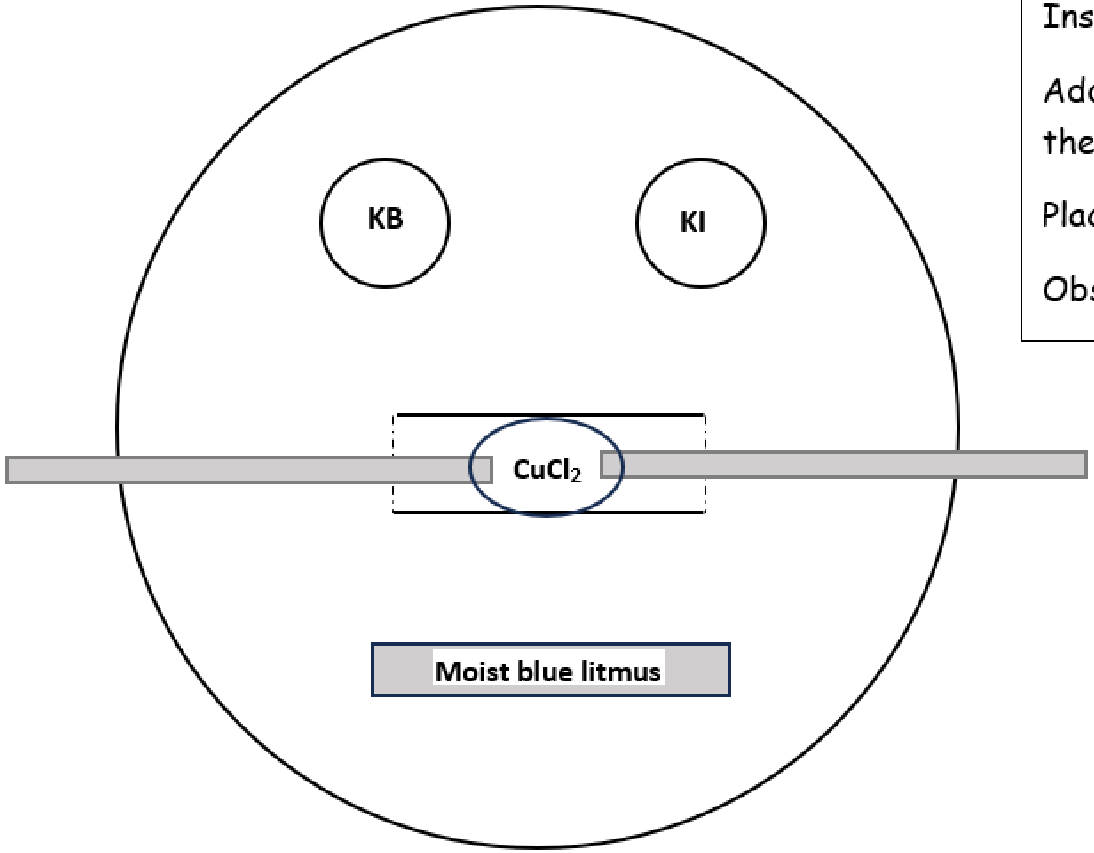
Chloride, Cl^-	Bromide, Br^-	Iodide, I^-	Carbonate, CO_3^{2-}	Sulphate, SO_4^{2-}

Examples of workshop activities

ELECTROLYSIS

This electrolysis uses carbon electrodes and a plastic channel to contain the electrolyte solution.

A lid on the Petri dish contains any harmful gases.



Wipe the petri dish clean between each experiment

Set up a circuit using a 9-volt battery / power supply and pegs to hold the carbon fibre electrode rods.

Place a Petri dish on the template.

Put 1 drop of KBr solution and 1 drop of KI solution in the circles as shown and place the indicator paper as indicated.

Insert the carbon electrodes into the plastic channel.

Add sufficient drops of copper chloride solution to cover the ends of both electrodes.

Place the lid on the Petri dish and turn on the power.

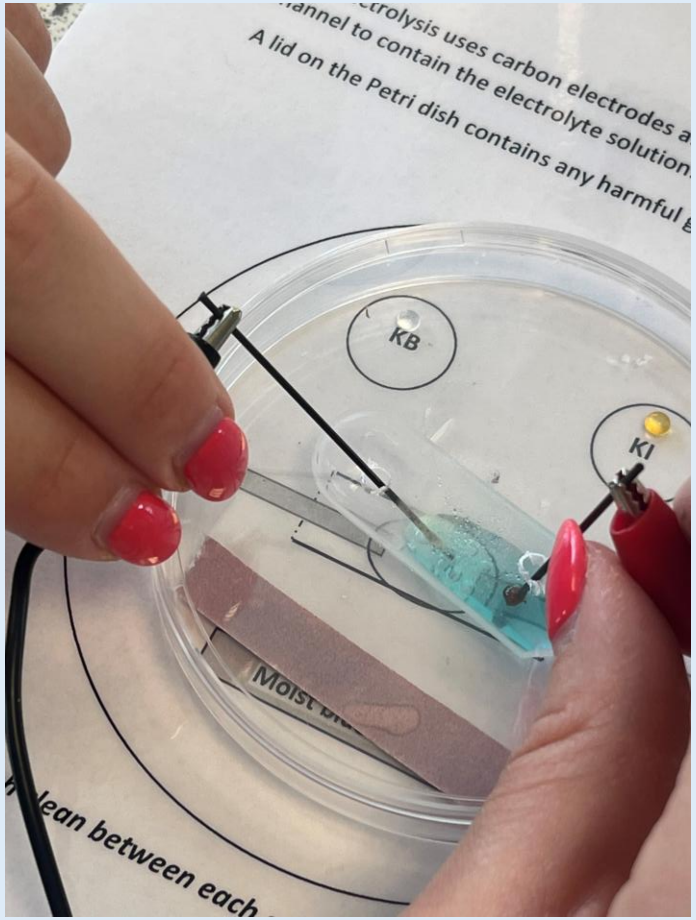
Observe and record your observations.

Other electrolysis experiments to try. Put the solution in the plastic channel.

- Potassium iodide with a drop starch solution.
- Silver nitrate solution.
- Sodium sulphate solution with a drop of UI solution.

https://science.cleapss.org.uk/Resource/PP059-Micro-electrolysis-of-copper-II-chloride-solution.pdf

Resources given to partner schools



Electrolysis of $CuCl_2$

A class set of resources- enough for 15 sets of experiments.

A traditional classroom set up for electrolysis

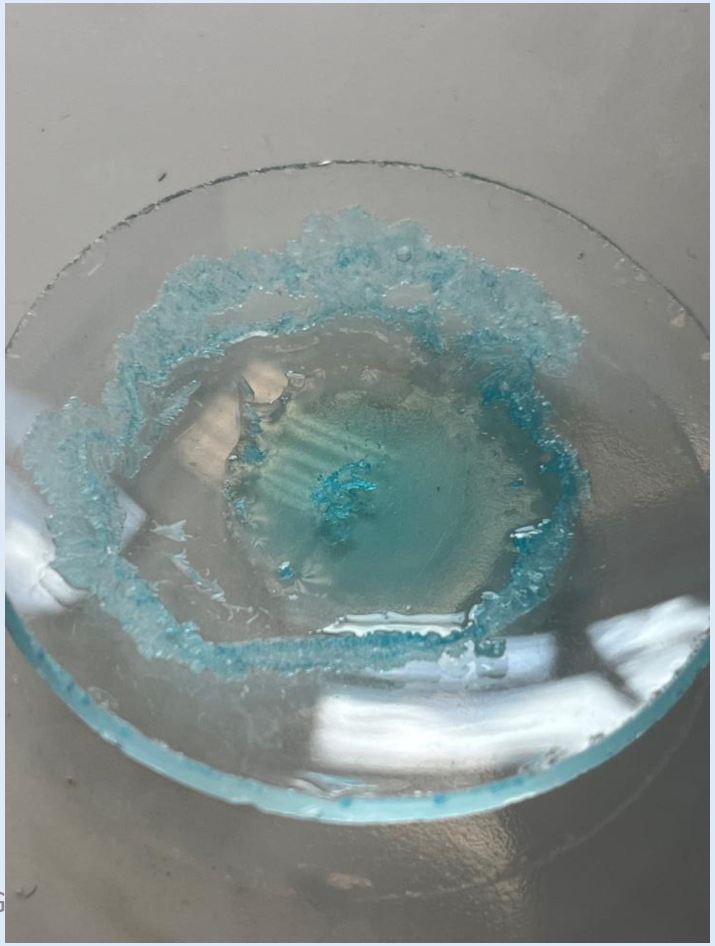
How might adopting microscale experiments as a pedagogic strategy support the teaching of chemistry lessons for 11-16-year-old children?

- Using microscale experiments as hooks at the beginning of lessons cements understanding.

- $Cl_2 + 2I^- \rightarrow I_2 + 2Cl^-$

How might adopting microscale experiments as a pedagogic strategy support teaching of chemistry lessons?

- Speed and safety of microscale allows time for discussion and dialogic talk



Does introducing microscale support ECTs develop experimental skills in their teaching?

- More inclusion of experiments with students between the 11 and 13 years of age. Practical can then be used as a tool to build the foundational knowledge of chemistry.

Conservation of mass → Moles calculations and theoretical yield → % yield calculations

- Microscale activities can be used as quick hands-on activities at the beginning of the lesson

→

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Limitations of microscale. How can we overcome these?

- Practical lab equipment does not look exactly the same as the required practical booklet. Hint - what are we assessing in practicals?

Initial findings

- Microscale is part of a pedagogic toolkit and does not necessarily have to completely replace traditional approaches to practical work.
- Microscale can get better results than traditional experimental approaches.
- Microscale is time efficient affording additional time for valuable metacognitive strategies such as dialogic talk in teaching.
- In introducing microscale as a pedagogic tool teachers will need to move away from preparation for terminal assessments as the sole purpose of education.

The Gatsby report

A report published in 2017 to highlight the importance of practicals in science.

A survey of experts in 11 countries was conducted to illicit 10 benchmarks for successful practicals.

1. PLANNED PRACTICAL SCIENCE
2. PURPOSEFUL PRACTICAL SCIENCE
3. EXPERT TEACHERS
4. FREQUENT AND VARIED PRACTICAL SCIENCE
5. LABORATORY FACILITIES AND EQUIPMENT
6. TECHNICAL SUPPORT
7. REAL EXPERIMENTS, VIRTUAL ENHANCEMENTS
8. INVESTIGATIVE PROJECTS
9. A BALANCED APPROACH TO RISK
10. ASSESSMENT FIT FOR PURPOSE

To what extent does deploying microscale experiments support teaching focussed on developing the skill of completing practical work effectively?

I think it can help a lot. Provides more flexibility around 'required practicals' to focus on what is important for each one. Saves teachers lesson time for everything else around doing the actual practical.

It can definitely help with the practical skills, but skills are less commonly assessed in the exam. In the exam, they need to be able to list a specific set of equipment.

Imagine you are conducting one of the aforementioned practicals In your plan consider

Planning a practical session

- How do you ensure student engagement?
- How do you promote scientific literacy?
- What is the purpose of the practical? What are your teaching aims?
- What misconceptions are you trying to address and how?
- How will you assess student understanding? What questions will you ask?
- What are the health and safety considerations?
- What are the student outcomes? How will students record the results? Write up?

First stop for further reading

Holman, J. (2017) *Good Practical Science*, London: Gatsby Foundation.[39]

This report is the result of an international study. It includes a useful literature review of available evidence and examples of good international practice.

Abrahams, I. and Reiss, M. J. (2016) *Enhancing learning with effective practical science 11–16*, London: Bloomsbury.[47]

This book provides a summary of research as well as example lesson plans for how to make practical work effective.